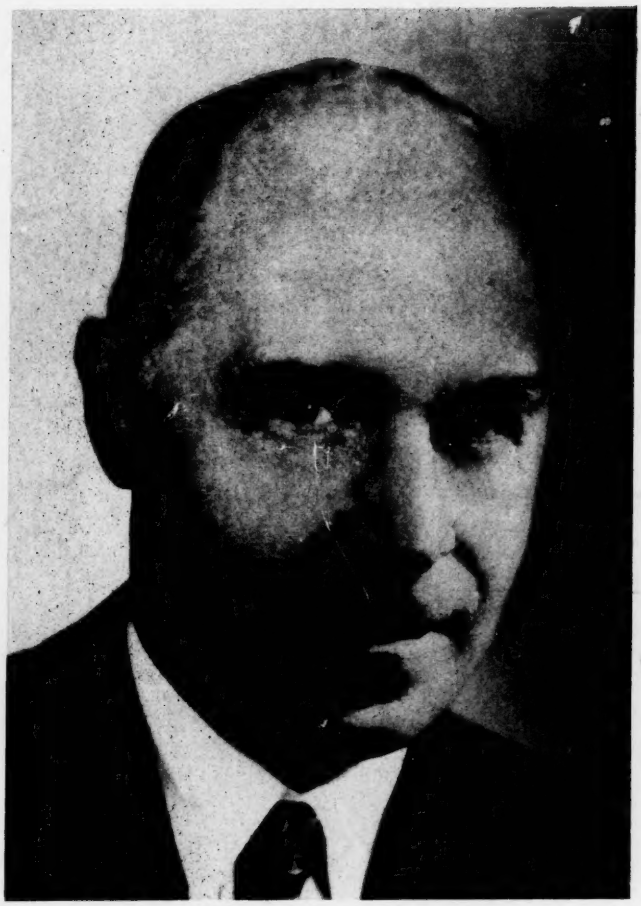
The Journal of HEREDITY



HERMAN J. MULLER
Nobel Laureate in Medicine

(SEE PAGE 325)

VOLUME 37 NOVEMBER, 1946 NUMBER 11

The American Genetic Association

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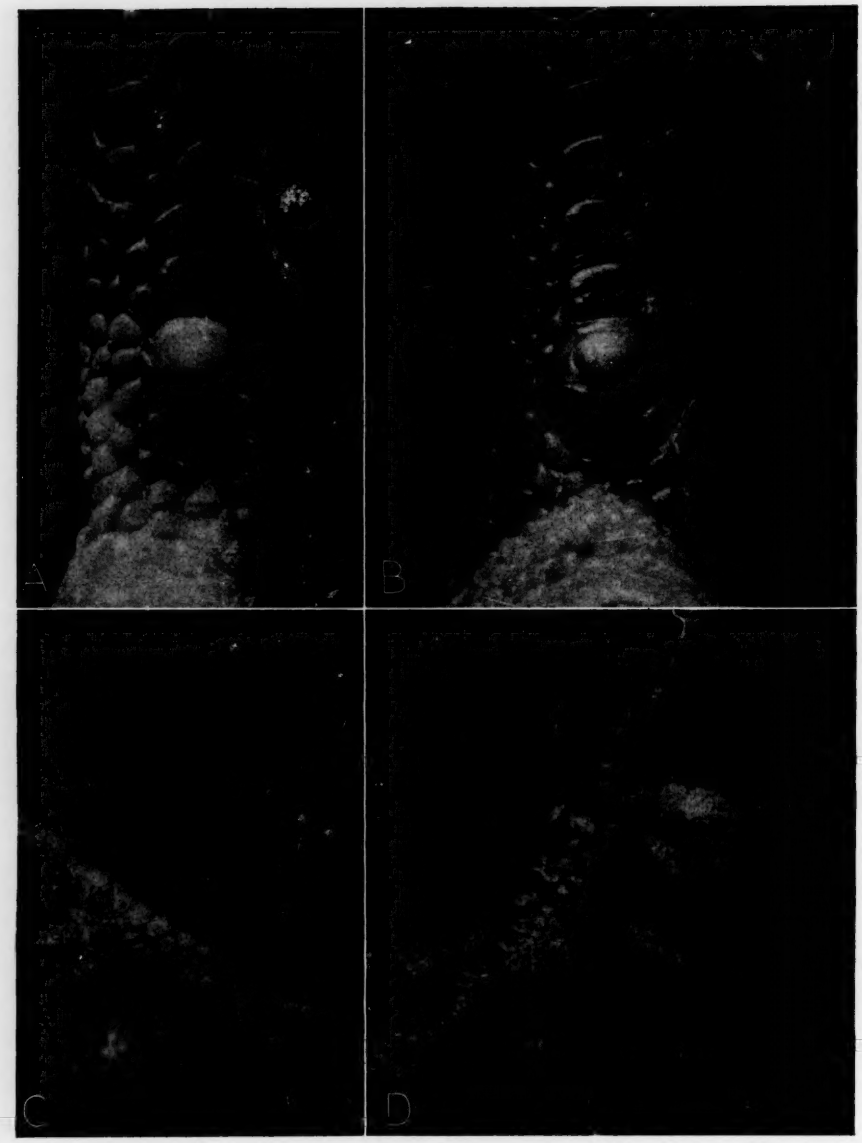

SPURS—YOUNG AND OLD

Figure 1

In the day-old chick the spur appears as a vesicle, single in the case of the normal spur (*A*), and twinned in the case of a double-spurred individual (*B*). Early adulthood initiates spur development, as shown in a cockerel (*C*). The mature cock carries even heavier armament (*D*).

DOUBLE SPUR INHERITANCE IN THE FOWL*

D. C. WARREN

Kansas Agricultural Experiment Station

THIS morphological variation was first observed in the Kansas State College poultry flock kept for genetic studies. It appeared in some miscellaneous stock having its origin in the Silkie Bantam. The first expression was noted in a day-old chick and more careful examination revealed the fact that the character was frequently occurring in this one mating.

Later studies showed that the character usually could be identified in day-old chicks, although it was true sometimes that chicks classified as normal at hatching, later were found to exhibit the doubling of the spurs. Some of the data included in the accompanying table were recorded from the day-old examination only, but it is not believed that the general results are changed by this possible source of error. Adult females ordinarily show little spur development but both at the one-day age and later dichotomy of the spurs could be identified in them. At hatching time whether normal or doubled, the spurs of males and females are identical in appearance. Irregularity in the structure and arrangement of leg scales at the region of the spur sometimes makes identification of spur doubling difficult in day-old chicks. In the case of hereditary multiple (triple) spurs[1] the day-old chick shows an apparent absence of spurs. In the double spurred condition there is usually a prominent divided spur on the newly hatched chick. The dichotomy may involve the spur on one leg only but usually it affects both. In the adult the two spurs on the one leg may differ in size, with the large spur occupying no fixed relative position. In the adult expression the division extends through both the integumentary portion and the bony core of the spur.

Domm[2] illustrates three ovariotomized Brown Leghorn chickens which show dichotomy of the spurs quite similar to that described here. Although all three birds came from the same flock Domm held the view that the dichotomy might be associated with the experimental treatment to which they were subjected.

Experimental Results

Our observations extended through four years and involved various types of matings. The data from these matings are included in Table I. A number of irregularities in mode of inheritance are observed in the accompanying data. First, in all matings there is a considerably higher incidence of double spurs among females. The results in the F_1 generation indicate that the factor is an autosomal recessive. There are, however, a few F_1 generation birds which show dichotomy of the spurs. In most instances the normal parent was from White Leghorn stock not known to carry double spurs so the exceptional F_1 individuals would appear not to be segregates. The double-spurred individuals in the F_1 generations are too numerous to be attributed to errors in the records. It should be noted that although the F_1 generation results seem to point to the recessiveness of double spur, the mating of double by double fails to give the expected one hundred percent of double spurs. In the backcross generation, where equal numbers of doubles and normals would be expected, there is a preponderance of double spurs in the females but the reverse is true of the males.

*Contribution Number 168, Department of Poultry Husbandry.

Since double spur and multiple spur have a similar influence on the structure of the spur it is of interest to determine how their combined effect might be expressed. Multiple spur is known to be an autosomal dominant while double spur behaves more like a recessive. An individual heterozygous for both these factors was backcrossed to double spur. Multiple spurs, double spurs, and normals were obtained but no unusual expression which might be interpreted as a combined effect was observed.

TABLE I. Inheritance of Double Spurs

	Females		Males	
	D.	N.	D.	N.
Double ♂ by Normal ♀ (1941)	7	27	..	38
Normal ♂ by Double ♀ (1943)	1	54	..	78
Total	8	81	..	116
F_1 ♂ by Double ♀ (1942)	33	16	39	42
F_1 ♀ by Double ♂ (1942)	49	40	33	57
F_1 ♀ by Double ♂ (1944)	19	13	8	25
Total	101	69	80	124
Double by Double (1941)	40	13	25	26
Double by Double (1943)	31	6	34	21
Total	71	19	59	47

Conclusion

It would appear that we are here dealing with a character which is autosomal and behaves in general as a recessive. There is considerable sexual dimorphism in its expression, irregularity in dominance, and poor penetrance in the homozygous state.

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✦

Transfer of Ovaries Between Different Breeds of Dogs

Dr. Leon F. Whitney reports in *Science* (103:654, May 24, 1946) of the successful transfer of ovaries between different breeds of dogs:

For a number of years, experiments have been in progress in an endeavor to transplant ovaries between dogs of different breed. The object of the present note is to report two successful transfers of this type and to record preliminary observations on the behavior of the recipient animals. Early unsuccessful experiments were carried out without regard to the physiological status of the dogs, and the present successful transfers appear to be directly related to the use of recipients in oestrus.

* * *

In both of the successful transfers the donors were bloodhounds and the recipients foxhounds. The bloodhounds were eight years old and had passed the period of productive breeding. The foxhounds were young animals, and each had whelped and raised one litter previous to transfer. Both were in oestrus at the time of operation.

Following transfer, signs of oestrus decreased gradually over a period of four or five days but then returned in full intensity and continued for a normal cycle of 20 days. Both dogs copulated during this period, but neither conceived. The dogs were followed carefully thereafter, and it was with considerable surprise that signs of a second oestrus were observed 49 days after the start of the previous period in one animal and on the 98th day in the other. It appears significant that such periods of heat do not correspond with the recipient's previous history, but on the contrary, represent a continuation of the bloodhound donor's cycles.

One of the dogs was killed for study 70 days after termination of the second oestrus. The ovaries appeared normal on gross examination, and histological section showed corpora lutea and innumerable follicles in various stages of maturation. An estimation of the number of follicles was not attempted, but it was at once apparent that they greatly exceeded the quantity normally found in the ovary of an eight-year-old dog. The hilus was of interest particularly in its content of blood vessels. Some of them were normal in appearance, filled with blood cells, and undoubtedly represented vascularization of the transplant by the new host. Others were necrotic or showed the extensive hyalinization characteristic of the senile ovary.

The behavior of the animals after operation as well as the morphology of the transplanted organs attest the successful transfer of ovaries between dogs of different breed. It is significant that each of the successful transfers was effected during the recipient's oestrus and that numerous experiments performed on other periods of the sexual cycle terminated in failure. The continuation of the donor's cycle after transfer was contrary to expectation and suggests that the initiation of oestrus is a function of the ovary rather than of the pituitary. These studies are being continued and will be reported in more detail in a later publication.

DR. MULLER RECEIVES NOBEL MEDICINE AWARD

HOW we know that X-rays affect organisms and tissues is a story with several strange, paradoxical and tragic chapters. Not the least fantastic of these is the award of the 1946 Nobel Prize in Medicine to a geneticist of whom perhaps a majority of doctors had never heard,* for a discovery made a generation ago which has been almost aggressively ignored by the medical profession.

In a world in turmoil through the explosion of The Bomb, this award emphasizes a very important truth: The Muller-effect has long been one of the most important tools for research into fundamental life processes; now it extends beyond the laboratory and becomes of urgent interest to every one of us. Not only did The Bomb bring quick or lingering death to a hundred thousand people, it temporarily sterilized several times that many, thus proving that they had been exposed to heavy enough radiation to have a profound and as yet undetermined effect on the germ plasm of the Japanese people.

We have been so appalled by the murderous effectiveness of The Bomb that we have not given much thought to the implications, in terms of Muller's discovery, of the effects of atomic warfare on those who survive. The Nobel Award Committee is to be commended for giving utmost emphasis to the fact that in the new-born Age of the Atom, Muller's discovery assumes a new and urgent importance to every human being. There was much talk of genocide at the Nuremberg trials, but one of the things we need to know right now is how genolytic is the bomb, i.e. how effective is it as a means of creating pools of lethal and deleterious genes? Muller pointed out at the time of the Nobel Prize announcement that we do not yet know the answer. But there is no reason to believe that a whiff of atomic energy is calculated to improve human germ-plasm.

That X-rays do affect living organisms has been learned the hard way; and the price of our knowledge is a row of graves, where a goodly number lie buried whose enthusiasms outran their caution. When Roentgen discovered X-rays in 1895, the foundations of physics were badly shaken, but biology seemed to lie outside the siesmic area. Medicine gained a new gadget which enabled pictures to be taken of people's insides, but this was hardly a cataclysmic development. Later various therapeutic effects were noted. Before very long it became clear that all was not well. Overexposure

*And for all the enlightenment the American Medical Assocation deigns to spread, they may still never have heard of him. The attitude of the AMA toward this problem is suggested by the handling of the announcement of the award to Dr. Muller in the *Journal of the American Medical Association*. Although this is one of the highest honors to which a member of the medical profession may aspire, the only mention of the award to appear to date (Dec. 15), is this paragraph near the end of the "Medical News" section, of the issue of November 9:

"Herman Muller Awarded Nobel Prize.—Hermann J. Muller, Ph.D., professor of zoology, Indiana University, Bloomington, has been awarded the Nobel Prize in medicine and physiology, it was announced October 31, for his work in discovering that 'mutations, or biological changes in species, may by produced by X-rays.' Dr. Muller's research throughout his career has been concerned with mutations and evolution. He joined the Indiana University staff in 1945, having resigned as professor of biology at Amherst College. Newspaper reports announce that the Rockefeller Foundation granted $95,000 to Indiana University last year for a six year research program in the field of genetics, and Dr. Muller was named as one of the three scientists to conduct it. The American Cancer Society made a grant of $4,500 to Dr. Muller last week for the study of cancer."

The fact that an important piece of medical news is buried in a perfunctory note in small type in an obscure list of routine notices is less important than that not the least cognizance is taken, and no background is given, of the tremendous medical implications of the discovery for which the award was made.

to the rays produced ugly slow-healing burns, loss of hair, and sterility. After the lapse of months or years the hands of workers routinely exposed to radiation developed cancerous lesions. Amputations of affected fingers or even hands only delayed a fatal termination; and many of the early workers with X-rays, in physics and in medicine, paid with their lives for their temerity in tinkering with this new force.

While this tragic chapter of the biological effects of the rays was being written, the science of genetics was coming into being. After thirty years in the dust-bin Mendel's experiments were rediscovered and genetics was born. Duringthe first quarter century of research the gene retained a heartening stability that defied the efforts of every experimental tinkerer. In 1927 all this was changed when Dr. Muller announced that genes as well as tissues were highly susceptible to the action of X-rays; and that wholesale mutations could be induced by ionizing radiation. Nine-tenths of these mutations were lethal and most of the remainder were deleterious, but this detracted not in the least from the theoretical value of the discovery. No one conceived that within a generation entire populations would be exposed to mass irradiations and that the implications of the Muller-effect would become a top-priority public health problem.

Biologists were quick to recognize that this discovery ushered in a new era in genetic research. Other geneticists quickly confirmed Muller's findings. In fact, Dr. L. J. Stadler, then working with plants, was on the verge of making the same discovery himself. Muller was awarded the 1927 AAAS prize for the outstanding discovery of the year, and other recognitions were extended by his colleagues.

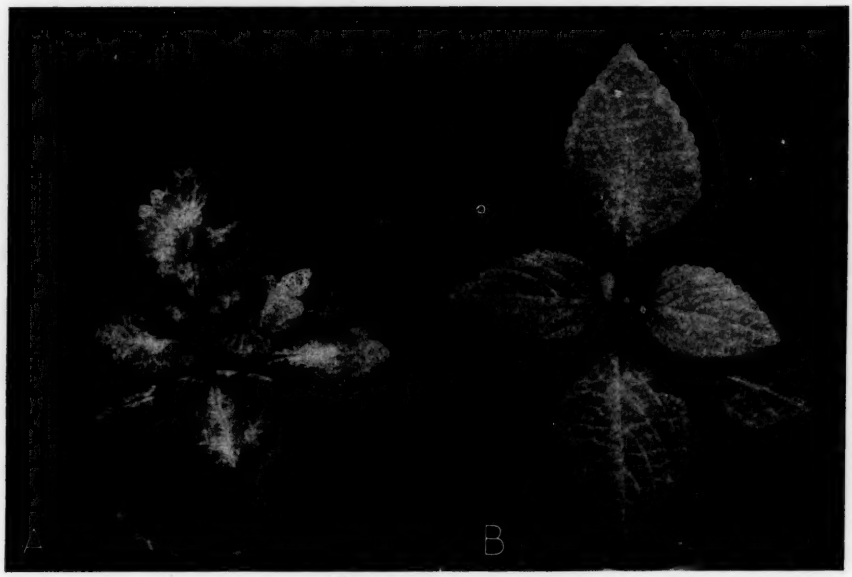
Significant as it was for genetics, the news of the discovery, and an understanding of its implications, did not extend very far. Medical use of X-rays for diagnosis and therapy continued without much change. Tolerances for X-ray dosage were established below which no quick untoward effects appeared. The use of X-rays as a convenient depilatory has been stopped. And the irradiation of the abdomens of women in the early weeks of pregnancy, resulting as it often does in the birth of a monstrous infant, is no longer practiced. By restraints such as these, many needless tragedies which were not uncommon in the early days of X-radiation are averted in current practice; but even today many radiologists do not consider it dangerous to irradiate moderately in later stages of prenatal development. This continues despite the discovery 20 years ago that there are hidden dangers to human gene plasm in the Muller-effect. Genetics experiments have made it certain that the effects of radiation on the genes are cumulative, and it has been definitely established that as little as 20 r-units will cause a measurable increase in mutation frequency. (An X-ray photograph requires at least 400 r-units of radiation.) Today thousands of hospital and laboratory workers are still exposed for long periods to considerable quantities of X-radiation—all cumulative in its effect. No wonder that geneticists, who have seen so convincingly what X-rays can do to heredity, are inclined to be shocked by an attitude which in the light of existing knowledge seems callously indifferent.

Dr. Muller's co-workers in genetics rejoice in this recognition of his discovery. They were the first to understand its great significance in terms of the health and welfare of millions of human beings. It is their hope that this award will serve to speed the wider acceptance and understanding of the Muller-effect and its implications.

Eventually, acceptance and complete understanding of the biological effects of ionizing radiation may help mankind to curb the malevolent forces and harness the beneficial forces of that dreaded mushroom-shaped genie which has recently emerged from Pandora's box. If so, the ideals of Dr. Nobel, the discoverer of dynamite, who out of fear at what he had wrought, decided to make *his* explosive the servant of humanity, will have been justified.—R. C.

GENES AND SPECIES DIFFERENCES IN COLEUS*

D. C. RIFE AND H. C. DUBER
Genetics Laboratory, Ohio State University†



"SPECIES" SEGREGATES IN F_2
Figure 2

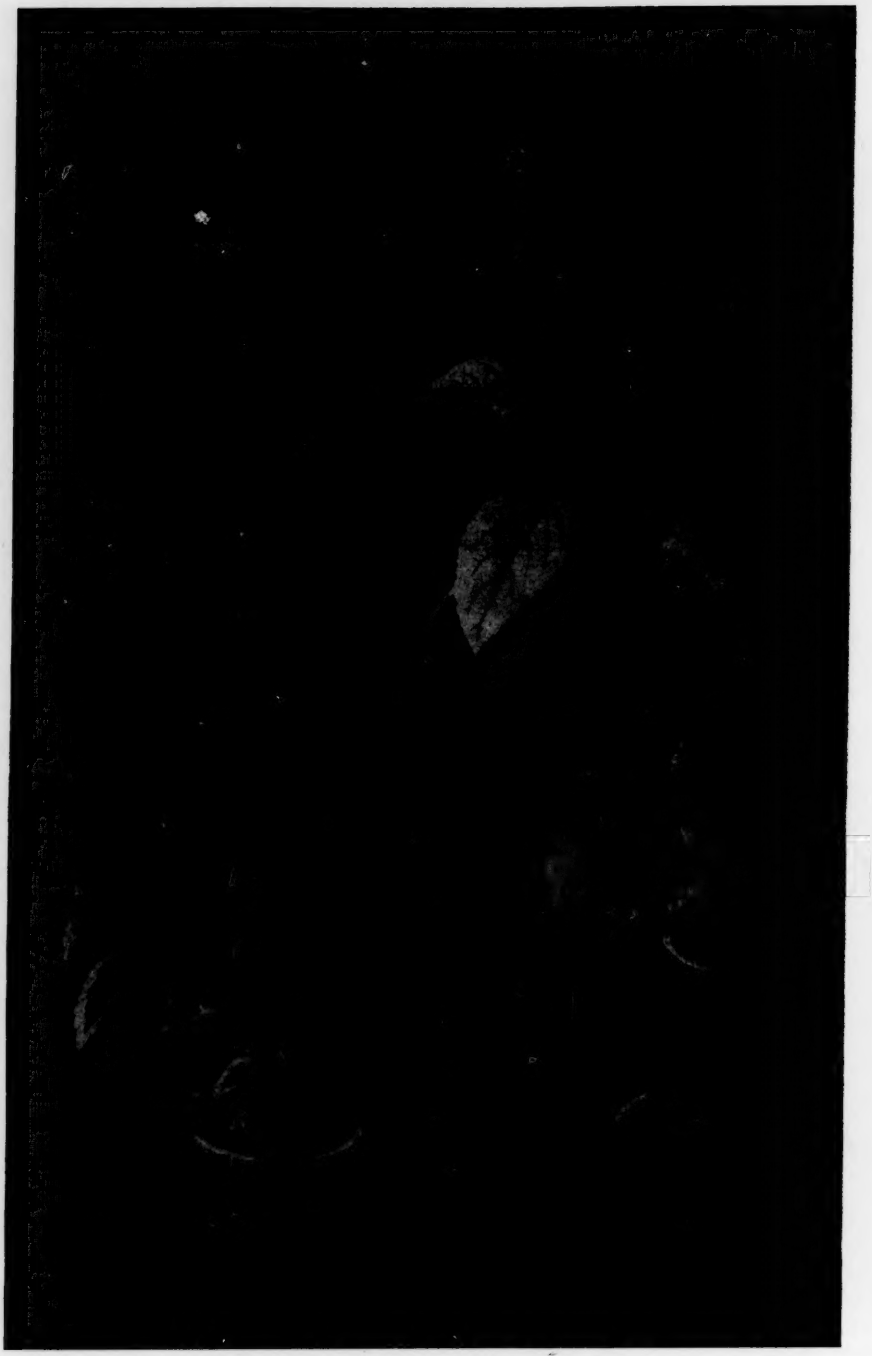
Characteristic appearance of the *Coleus* "species" *laciniatus* (*A*), and *blumei* (*B*). These plants are F_2 sibling segregates of a green irregular leafed plant resulting from a cross between *C. blumei* and *C. laciniatus*. Both are solid green.

MOST of the common commercial varieties of coleus are assumed to belong to species *blumei*. Several years ago some seed, described as being from coleus plants of species *laciniatus*, was sent to us from the Botanical Gardens at Buitenzorg, Java. The characteristic appearance of plants grown from this seed is shown in Figures 2*A* and 4*A*. Characteristic plants of *blumei* are shown in Figures 2*B* and 4*B*. Note the unusual type of veination in *laciniatus*. The veins anastomose in a peculiar manner and form a more or less oval area. Such leaves usually curl or roll inward from the sides. The leaf margins are more irregular than those of *blumei*. Henceforth we shall refer to these peculiar characteristics of *laciniatus* as irregular leaf.

A gray plant of species *blumei* was crossed with a patterned plant of species *laciniatus*. Gray color[1] is due to the heterozygous condition of the genes for purple (P) and green (p^G). Pattern is due to another allele of this same series (p) which is recessive to both P and p^G.

Several progeny were obtained from

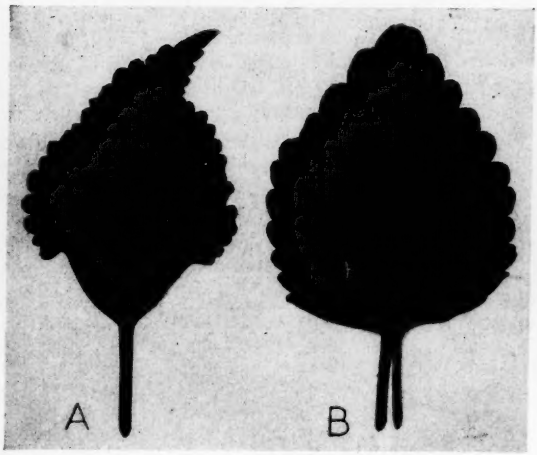
*Genetic Studies of Coleus No. VI.
†Department of Zoology and Entomology.



PATTERN AND SEMI-PATTERN ALLELES

Figure 3

Patterned coleus plant on the left, semi-patterned plant on the right. Note that the lower leaves of the semi-patterned plant show much more extensive colored areas than do the upper leaves. Both plants shown here have regular veination of the leaves.



"SPECIES" DIFFERENCES IN VEINATION

Figure 4

Undersurfaces of coleus leaves showing veination characteristic of irregular and regular leaves. *A—C. laciniatus*; *B—C. blumei.*

the cross. All had irregular leaves, identical with those of *laciniatus*. About half of the plants were solid green, and half of them solid purple. Two of the green, and one of the purple plants were selfed, and each produced offspring in the ratio of approximately three irregular to one regular leafed plant (See Table II*). One of the purple irregular leafed plants was backcrossed to a regular leafed plant, and produced approximately equal numbers of irregular and regular leafed progeny. Thus, irregular leaves appear to be due to a single dominant gene, which we shall designate by *G*.

In respect to color, the purple plant which was selfed produced offspring almost exactly in the ratio of three purple to one pattern. Each of the green plants, when selfed, produced ratios of approximately three solid green to one with colored, non-uniform leaf markings which we shall designate as semipattern. These results indicate that another allele of the purple series,[2] recessive to pattern, must have been present in the *laciniatus* plant used in the original cross. As the plant was patterned in phenotype, semi-pattern must be recessive to pattern. We shall use p^{-m} to designate the gene for semi-pattern. (See Figure 3).

The genotypes and phenotypes used in the original cross and their offspring which in turn produced the F_2 listed in Table II are as follows:

blumei ($Pp^{G}gg$) Gray, regular leaves	×	*laciniatus* ($pp^{-m}GG$) Patterned, irregular leaves
	F_1	
blumei ($PpGg$) Purple, irregular leaves		*laciniatus* ($p^{G}p^{-m}Gg$) Green, irregular leaves

An analysis of the progeny of one backcross and three F_2 plants gave ratios none of which deviated significantly from those expected on the basis of this hypothesis. Presumably the color alleles and the genes responsible for regular versus irregular leaves are not linked. The discovery of the gene for semi-pattern now makes a total of six alleles in the purple series. Of the 21 possible genotypes sixteen have been synthesized, and the leaf colors observed (Table I).*

Cytological examination indicates that both *blumei* and *laciniatus* have the same

*Table I, giving the genotypes and phenotypes of the purple allelic series, and Table II, giving the F_2 and backcross distribution obtained and expected are available as a supplementary document. To obtain this material order Document No. 2328 from American Documentation Institute, 1719 N St., N. W., Washington 6, D. C., remitting 50c for each microfilm or photocopy.

number of chromosomes (20 pairs). Regular and irregular leaves are the only apparent differences between plants of the two species. This is due to a single pair of genes. Both have the same color factors, and the two species are highly inter-fertile. Coleus plants with irregular leaves are sometimes found in commercial greenhouses.

In view of these observations are *blumei* and *laciniatus* really different species?

Summary

1. A dominant gene (G) is responsible for irregular leaves in coleus.

2. A recessive gene (p^{-m}) in the purple color allelic series results, in the homozygous condition, in the type of leaf coloration known as semi-pattern.

3. The alleles determining whether leaves are regular or irregular (G,g) and those of the purple color series do not appear to be linked.

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◆

Army Finds Inherent Differences in Taste Perception

In 1932 A. F. Blakeslee and A. L. Fox demonstrated that ability to distinguish taste differences varies greatly between individuals, and from one substance to another. (*Journal of Heredity*, March 1932.) Large-scale experiments with phenyl-thio-carbamide revealed a wide range of reactions, from the acute taster who could detect the substance in a highly diluted solution to the "non-taster" to whom even the most concentrated dose was completely tasteless. The results showed that non-tasting is inherited as a recessive characteristic.

The Army, while not concerned with the genetic aspects of tasting, is making extensive tests of taste differences in order to perfect a ration that will be palatable under the various circumstances in which it is likely to be consumed.

According to a recent U. S. Army press release, the Quartermaster Corps has found that about 20 persons out of 100 have taste perceptions so accurate that they can tell the difference between canned bread that has been stored for two weeks at 70 degrees temperature and a similar item stored for the same length of time at 100 degrees.

Some persons, the tests revealed, have accurate taste perceptions for some foods but not for others. There are some who cannot distinguish the difference between a glass of clear water and one heavily saturated with quinine.

At the Quartermaster Food and Container Institute for the Armed Forces, at Chicago, under the guidance of a civilian committee on food research, subsistence experts seeking to find foods with satisfactory military requirements are utilizing carefully selected food tasters to help them in their research.

These persons are chosen to find the differences in taste, odor, and texture of a particular article of food only after their perceptions on that item have been tested. If they are to be used in testing a sample of canned bread they first must be able to distinguish between similar items which have only slight differences in flavor.

A good taster, the experts say, will be right 12 or 13 out of 15 trials, while the poor taster who relies on faulty perceptions or guessing may rate no better than 50-50. The prospective taste testers in the Quartermaster Institute are given no helpful hints—in fact the job is made difficult in that they are deprived of knowing the color or appearance of the item under test.

The Quartermaster Corps learned during the war that many factors are concerned in the acceptability of foods. An item that may be relished when eaten only a few times is often rejected after constant repetition. A certain food may be acceptable to a soldier who is accustomed to eating it but will be spurned by one not familiar with it. Environmental conditions have a strong influence on acceptability, so also have the appearance, texture, and taste of the food itself. There is a difference whether the food is served hot or cold.

A large amount of information is being compiled from the results of these taste tests. It has been found possible to ascertain percentages of acceptability for different foods under varying conditions of stability. One test, with a large group, gave a unanimous decision rating beef and gravy ahead of all other items served. Only 50 percent of the testers would even sample escalloped oysters but all of those who did eat the escalloped oysters rated them second best. Thus it was found in this test that while escalloped oysters might be acceptable to only 50 percent of a group, they are highly acceptable to that 50 percent.

A FREAK BLACK-EYED-SUSAN

WILLIAM A. DAYTON

Forest Service, U. S. Department of Agriculture

THE great variability of the black-eyed-susan (*Rudbeckia hirta* L.) has been commented upon by numerous authors, including Beal,[3] Blakeslee,[4] Clute,[6] and Davis.[7] Teratological forms have been mentioned or described by W. W. Bailey,[2] Buckman,[5] Lucas,[8] Penzig,[9] Rothrock,[10] Small,[11] and others.[1]

Dr. Herbert N. Wheeler, a former officer of the U. S. Forest Service, now retired, recently called my attention to a bizarre black-eyed-susan collected near Great Falls, Fairfax County, Virginia, by Mr. John Bittner, a pharmacist of Washington, D. C. Mr. Bittner kindly lent me his specimen for examination and photographing and has assented to my publishing this description of it. Figure 5 shows this plant, reduced one-fourth, propped in a small vase; unfortunately the plant was somewhat wilted from the fine fresh condition in which Mr. Bittner handed it to me from his refrigerator. I am indebted for the photograph to the photographic section of the Forest Service Division of Engineering.

The specimen was cut off about six inches from the ground and was about 18 inches high. It consisted of a flattened stem (an excellent example of the "ribbon-growth" mentioned by Worsdell[12]) which, about 5½ inches from the base, separated into two much flattened stems ¾ to 1 inch wide, bearing scattered leaves. Each of these two forks terminated in a fasciated head which appeared to be a compost of three fused heads whose disks formed an elongated brown central band about 3 inches long. The achenes were very immature. From near the base of the specimen emerged a greatly depauperate but otherwise normal stem bearing a diminutive but typically formed head. Several of the authors cited below report fasciations in

FASCIATED SUSAN

Figure 5

Teratological specimen of black-eyed-susan (*Rudbeckia hirta*) collected by Mr. John Bittner of Washington, D. C. × .25.

Rudbeckia hirta. For example, Davis[7] mentions "fascicled stems" and Bailey[2] (1891) cites a case of four heads fasciated in a rosette. Rothrock's case[10] is even more remarkable. However, I do not recall having read or heard of a case closely resembling Mr. Bittner's plant, although the illustration in Miss Buckman's article[5] is of a somewhat analogous condition. Bailey's plant[2] (1891) also may possibly have been in a similar

category, but he mentions that the leaves had very long petioles and the disk was longitudinally fissured, characters not represented in Mr. Bittner's specimen.

It is interesting to speculate on the possible etiologies of this freakish phenomenon. Could some mutilation or physiological disturbance or imbalance produce such a growth? Do nemas or other parasitical organisms possibly play a role in similar teratisms? Is this condition inherited or transmissible and does it reflect some genic malady? Whatever the cause, Mr. Bittner's black-eyed-susan has definitely, in street lingo, "gone haywire"!

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Radcliffe Offers Genetics Fellowship

Radcliffe College has announced that applications for the Helen Putnam Fellowship for Advanced Research in the field of genetics or of mental health would now be received by the college.

This fellowship, carrying a stipend of $2,000 for an eleven-month period from October 1, 1947, is open to mature women scholars who have gained their doctorate, or who possess equivalent qualifications and who have research in progress. Applications for the award should be submitted to Radcliffe College not later than April 1.

All normal laboratory facilities will be provided to the winner of the Putnam Fellowship, whose appointment will be announced about May 1st by the Committee on Award which includes W. K. Jordan, President of Radcliffe College and the following members of the Harvard University faculty: Arlie V. Bock, Professor of Hygiene; Stanley Cobb, Professor of Neuropathology and Psychiatrist-in-Chief, Massachusetts General Hospital; Alden B. Dawson and Leigh Hoadley, Professors of Zoology; Karl Sax, Professor of Botany and Edwin B. Wilson, Professor emeritus of Vital Statistics.

The first Putnam Fellow, Dr. Frances Jones Bonner, appointed for 1946-47, is now carrying on research on hereditary and social factors in hysteria.

FAMILY SEX RATIOS IN THE FOWL

L. N. Hazel and W. F. Lamoreux

Kimber Poultry Breeding Farm, Niles, California

SEX ratios have been studied extensively because of their relation to the problems of sex determination and sex differentiation. Several attempts have been made to modify normal sex ratios by selecting high "male-producing" or "female-producing" strains of animals.[4, 5, 7] Similar efforts seem not to have been reported for the domestic chicken, although cases of extreme deviation reported by Hays,[2] Jull,[3] and Mussehl[6] have indicated that some modification of the normal sex ratio may be possible. In the reference cited[2] Hays concludes that "It is not at all unlikely that sex in domestic chickens may depend upon many genes, and that many of these are located in the autosomes." If this be true, it should be feasible to modify the sex ratio by selection.

This study was undertaken to obtain information concerning the magnitude and nature of variations in the family sex ratio in a large flock of White Leghorns.

Experimental Material

The data were obtained from chicks hatched in a "polyallel" series of matings during a period of 19 weeks in the spring and summer of 1944. Sixty pens of six females each were mated to 60 males in four successive series. Thus each male had six mates, all of them in one series, and each hen had four mates, each in a different series. Each series of matings terminated at the end of five weeks, hatching eggs being saved during the last four weeks only. Eggs were set at weekly intervals and the chicks from each family were hatched in an individual basket. The sex of all chicks hatched was determined by inspection of the cloaca except for obviously crippled or defective individuals.

The data from only 29 pens were used in the computations, comprising those pens in which at least four hens had a minimum of eight chicks from each of the four matings. This procedure gave 464 full-sib families from 116 males and 116 females with an average of 18 chicks per family. The data were analyzed as suggested by Cochran[1] for binominal data where the extraneous variation is small.

Results and Discussion

The average sex ratio for each of the four series of matings is given in Table I. Since the lowest and highest ratios occurred in the second and third series, there was no consistent trend in the sex ratio as the hatching season progressed. The average sex ratio for the entire group of 8,355 birds was 49.79.

A summary of the analysis of variance is given in Table II. The size of the mean square between paternal half-sibs, between maternal half-sibs, and between full-sibs, relative to the mean square within families is of particular interest in the present study. This analysis was intended to provide a test of several more or less logical hypotheses concerning the nature of variations in the sex ratios.

First, the presence of sex-linked embryonic lethal genes would tend to increase the sex ratio among progeny of heterozygous sires and thereby would have increased the variation between the sex ratios of paternal half-sib families. This would have been reflected in the mean square between paternal half-sib families in Table II.

Second, autosomal genes with effects sufficiently pronounced to influence sex would have increased differences between family sex ratios in all three family groups with an attendant increase in the corresponding mean squares, mak

ing them greater than the mean square "within families."

Third, complementary genes with effects upon sex only in particular combinations of matings would have increased the mean square between full-sib families without having an appreciable effect upon the mean squares between paternal or maternal half-sib families.

Fourth, even in the absence of special genes of the kinds mentioned above, a non-random segregation of the sex chromosome in the female still might have occurred, perhaps induced by hormones or other genes. In this event the mean square between maternal half-sibs would have been larger than the mean squares between paternal half-sibs, full-sibs, and "within families."

The mean squares for the three kinds of sibs given in Table II are actually slightly smaller than the mean square within families, indicating that the family sex ratios differ among themselves no more than would be expected by chance. Further evidence that this is true is provided by the fact that the mean square for each of the sibships differs but slightly from the binomial variance, $p(1-p)$. If p be taken as the fractional sex ratio, 0.4979, from Table I, the binomial variance is 0.250, to be compared with 0.224 (between paternal half-sibs), 0.244 (between maternal half-sibs) and 0.239 (between full-sibs).

These data provide no evidence that sex linked lethal genes, autosomal modifiers of sex, complementary genes, or non-random segregation of the sex chromosome had any measurable effect upon variations in the family sex ratios in this population. If such factors were present, their frequency was so low that their effects were concealed by the binomial variation in the sex ratio. The detection of very rare genes of this sort would require special matings among birds from families with extreme sex ratios.

TABLE I.—The number of chicks and average sex ratios in each of the four series of matings.

Series	1	2	3	4	Total
Number of chicks	1937	2091	2153	2124	8355
Percent males	49.57	47.97	51.97	49.58	49.79

TABLE II.—Analysis of variance of family sex ratios.

Source of variation	Degrees of freedom	Mean square
Total	8355	0.250
Between series	3	.580
Between pens	28	.241
Between paternal half-sibs	84	.224
Between maternal half-sibs	87	.244
Between full-sibs	261	.239
Within families	7891	.252

Summary

Family sex ratios were studied in a group of 8,355 White Leghorn chicks hatched during 1944 in a "polyallel" experimental design which included 464 full-sib families. The average sex ratio was 49.79.

The experimental design and analysis were intended to measure the effects of sex linked lethals, autosomal modifiers of sex, complementary genes, and the non-random segregation of the sex chromosome upon the variation in family sex ratios. The observed differences among the sex ratios of paternal half-sib families, maternal half-sib families and full-sib families were no larger than expected to result from the random segregation of the sex chromosome into ovum or polar body during meiosis.

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LINKAGE STUDIES WITH THE PIROUETTE GENE*

In the Mouse

MARGARET M. DICKIE AND GEORGE W. WOOLLEY

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Bar Harbor, Maine

PIROUETTE, a choreic mutation, occurred in 1943 in the "low tumor" strain C_3H mice (*Mus musculus*)[1]. The mutant mouse was subsequently tested with other mutations of choreic nature, jerker (*je*), waltzer (*v*), shaker-1 (*sh-1*), shaker-2 (*sh-2*), and all the offspring were normal; therefore the mutant was not one of these and was not comparable to the descriptions of fidget and Bochum waltzer. The character was recessive and designated by the symbol *pi*.

Classification in the present study was made when the mice were from ten to fourteen days of age, at which time backing or crab-like movements as well as pirouetting were very marked.

Linkage was first looked for with some of the dominant genes.† In the test with rex (Cross, *Rere Pi pi* × *re re pi pi*), at present an independent gene, the results were negative (See Table I). A new dominant spotting mutation, splotch‡, was tested with negative results. Next, the agouti and albino loci, on the fifth and first chromosomes respectively, were tested for possible linkage and found negative. The results of these crosses, *AaPipi* × *aapipi*, with 40 animals, and *CcPipi* × *ccpipi*, with 79 animals are also shown in Table I. Dilution (*d*), on the second chromosome, and brown (*b*), on the eighth chromosome, were tested. A total of 64 animals gave negative linkage for both loci. One cross included a sixth chromosome locus, caracul (*Ca*), a ninth chromosome locus, fused tail (*Fu*), and a third chromosome locus, viable dominant spotting (W^v).

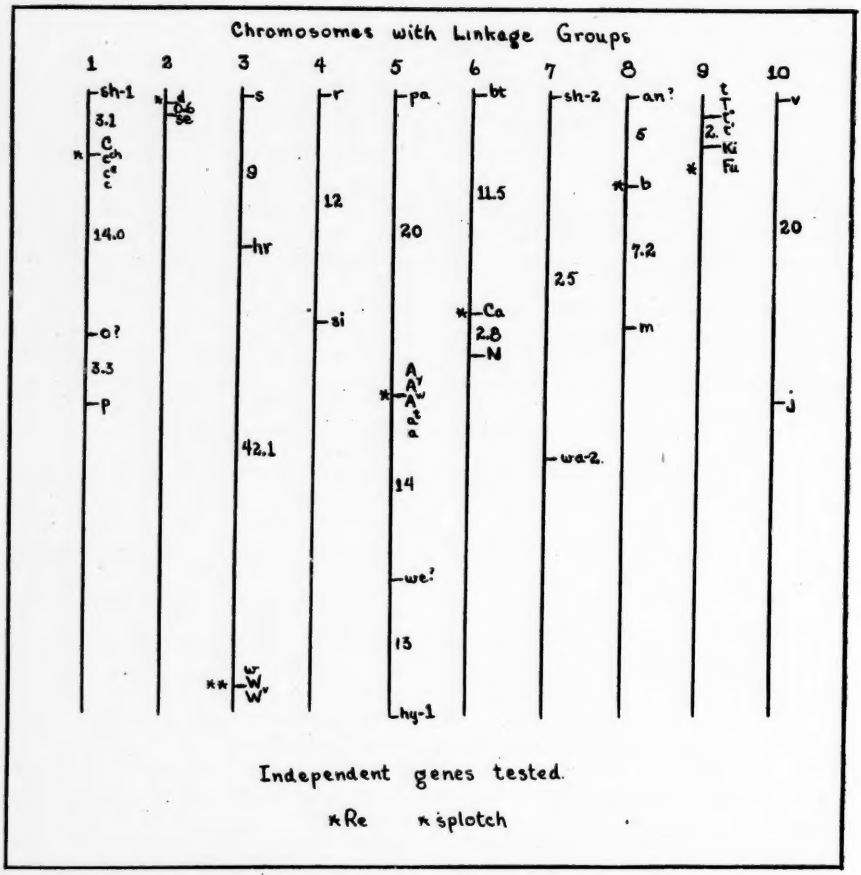
The crosses were made as follows: *Caca* W^vw *FufuPipi* × *caca wwfufupipi, CacaW*^{v}*w Pipi* × *cacawwpipi* and W^vw *FufuPipi* × *wwfufupipi*. Classification of 208 animals indicated that there was linkage with viable dominant spotting (W^v), an allele of dominant spotting (W). Pirouette was 7.2 cross-over units from viable dominant spotting. In tests with a heterozygous female parent, the cross-over percentage was 5.3 with 94 animals, all from one female. When the male was heterozygous, the cross-over percentage was 11.4 with 114 animals. The difference, however, was not statistically significant.

Since pirouette was linked with viable dominant spotting and the linkage data were negative with albinism, agouti, rex, caracul, and fused tail, it was assumed that other genes closely linked with those tested genes would be negative also. Many have already been tested with viable dominant spotting and found negative. Tests are now being carried on with hairless (*hr*). This is necessary because a loose linkage (42.1%) between hairless and viable dominant spotting has been found [2], and the test should determine the position of *pi* with respect to W^v. (See Figure 7.)

*This work has been aided by grants to the Roscoe B. Jackson Memorial Laboratory from the Commonwealth Fund, Anna Fuller Fund, Jane Coffin Childs Memorial Fund, and the National Advisory Cancer Council.

†Thanks are extended to Dr. G. D. Snell of this laboratory for donating many of the genes used in these linkage tests.

‡This is an unreported mutation from the stocks of Dr. W. L. Russell of this laboratory, and was tested because it was present in an animal which carried rex.

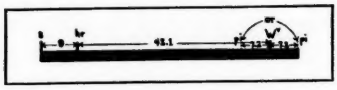


* Test for linkage negative
** Test for linkage positive

LINKAGE MAP OF MOUSE GENES

Figure 6

The mouse has 20 pairs of chromosomes; and ten linkage groups have been established, involving thirty gene loci. Pirouette is located on chromosome 3, near *W*, but its relations to *hr* have not been established.



W^v BRACKETED

Detailed map of chromosome 3, showing location of its known genes, and possibilities for location of the pirouette gene. Cross-over units between the genes are given also. s = recessive spotting, hr = hairless, W^v = viable dominant spotting, pi = pirouette.

TABLE I.—Linkage data on genes tested with pirouette (*pi*), showing negative and positive linkage

pi tested with	Total Animals Tested	Cross-over Percentage
Re	228	47.8
Splotch	228	54.4
c	79	46.8
d	64	56.2
b	64	51.6
A	40	65.0
Ca	157	52.2
Fu	124	50.0
W^v	208	7.2*

*Indicates linkage.

Also tests with such gene locations as pallid (*pa*), twenty units away from the agouti locus, which has not been tested with any of the genes on chromosome 3, that is, recessive spotting (*s*), hairless (*hr*), and dominant spotting (*W*), or viable dominant spotting (W^v), are being tested with pirouette for possible further linkages.

Summary

Pirouette (*pi*), a recessive choreic mutation, has been found to be linked with viable dominant spotting (W^v) with a cross-over percentage of 7.2. Further tests are being carried on to determine, if possible, the location of pirouette on the third chromosome.

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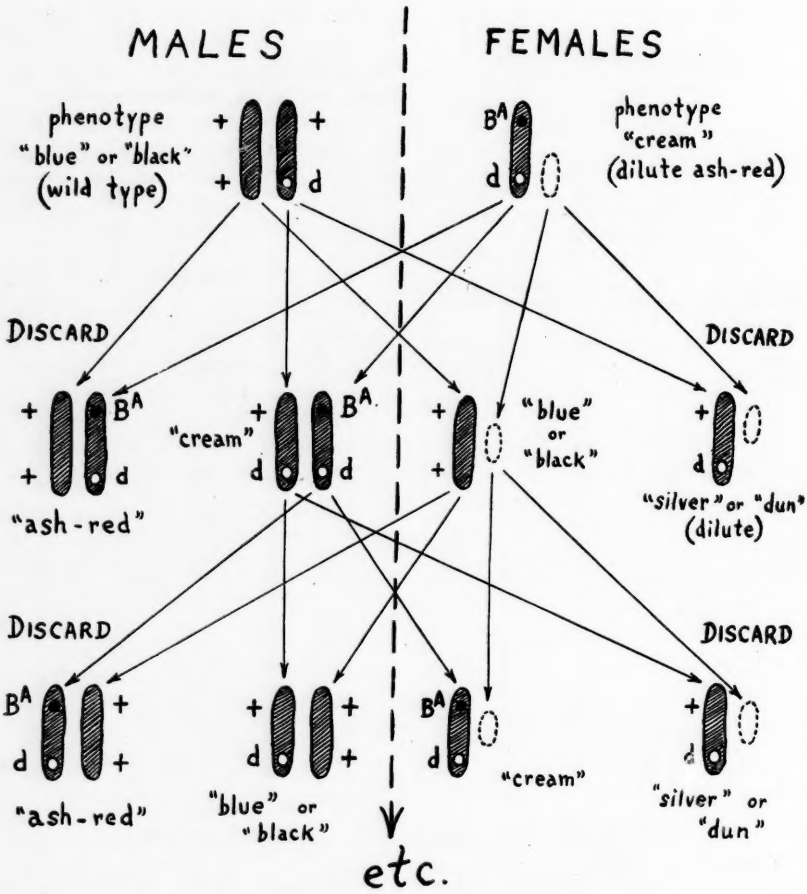
Fels Institute's Program and Facilities Expanded

The Samuel S. Fels Fund of Philadelphia announces the erection of a new research laboratory building on the Antioch College Campus at Yellow Springs, Ohio. The new building, to cost about $400,000, exclusive of equipment, is to house the activities of the Fels Research Institute. The Institute's program, devoted to the study of growth and development of children, is being expanded considerably in the following areas: Biochemistry with emphasis on blood and urinary enzymes, vitamin adequacy, ketosteroids, estrogens and other hormones, in relation to growth progress and behavior; Genetics with emphasis on the inheritance of biochemical and physiological function patterns and growth patterns; Physiology with emphasis on resistance level to physical or emotional stress in relation to predisposition to psychosomatic disease and personality.

To house these activities and those of the Psychology and Physical Growth sections, physiological, physical growth, biochemical and psychological laboratories, as well as office and library space will be provided.

A new scientific advisory board has been created consisting of Dr. Robert Yerkes, Yale, psychobiology; Dr. Ashley Weech, Cincinnati University, pediatrics; Dr. E. V. Cowdry, Washington University, anatomy; and Dr. Maurice Visscher, University of Minnesota, physiology. The Institute, established in 1929, is under the direction of Dr. L. W. Sontag.



SEX-LINKED FACTORS CRISS-CROSSED

Figure 8

A diagram to show the distribution of the sex chromosomes in "ersatz auto-sexing" of pigeons. The "W" chromosome (or lack of one chromosome) in females is indicated by the small unshaded chromosome figure. Phenotype names are enclosed in quotation marks. The factor symbol B^A represents the dominant mutant "ash-red," and *d* represents the recessive mutant "dilution." Plus signs are the customary symbols for the wild-type alleles. By banding squabs in the nest accurate sex-identification is assured. To perpetuate the system it is only necessary to pair opposite types, continuing to discard all "ash-red" males and "silver" or "dun" females.

"ERSATZ AUTO-SEXING" IN PIGEONS

C. M. GOTTFRIED AND W. F. HOLLANDER
Stamford, Conn., and East Haven, Conn.

SINCE pigeons lack external anatomical male or female signs, sex recognition is a perpetual problem for the breeder. The discovery early in the century that certain colors are sex-linked offered a partial solution to the problem, but few breeders ever used the principle. One reason was that in the typical "criss-cross" mating, the offspring were not usable in turn.

The announcement of a permanently sex-dimorphic color effect, "auto-sexing," in 1942[1] seemed to offer a final answer to the breeders' difficulties. However, the new color factor involved requires much time for dissemination and incorporation into standard breeds. Furthermore, there is a natural reluctance in many instances to toss long-established color varieties overboard.

Readers of the JOURNAL OF HEREDITY may be interested in the following simple scheme by means of which the previously well known and fairly common sex-linked colors may be juggled to give most of the advantages of auto-sexing. Although at present uniquely applicable to pigeons, the method may have future possibility in other species of birds.

The trick is to use two *sets* of sex-linked factors in the mating simultaneously, and in the repulsion phase. In brief, males (the homogametic sex in birds) heterozygous at one locus and homozygous recessive at another locus are mated with females (hemizygous or heterogametic sex) having a recessive allele at the first locus and a dominant allele at the second locus. In the progeny, all of which may be sexed by the criss-cross inheritance, there will again be appropriate types for mating. The two additional types produced may be routinely eliminated (sold). The same process is repeated every generation, the discard types being always the same. As long as opposite types of the two retained phenotypes are mated, there is no need to keep track of generations. It is essential that the birds be banded in the nest, so that no errors may be made regarding sex-identification.

We have called this system "ersatz auto-sexing," but it might also be termed *reciprocating sex-linked mating.* In Figure 8 the method is demonstrated, using as examples the factors reported on by Cole and Kelley in 1919.[2] These are widespread among breeds of pigeons, and well known to breeders, though the color nomenclature is not entirely standardized. It is surprising that no one has hitherto realized that they could be exploited so effectively.

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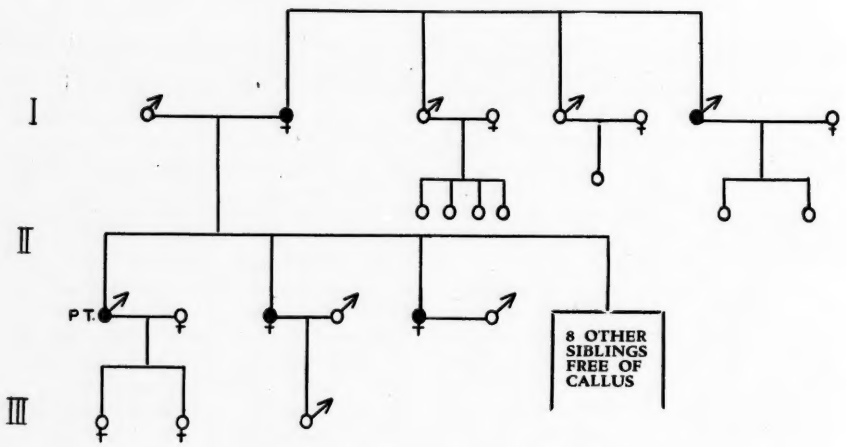
Sex Identification in Baby Chicks of "Red" Varieties

The accuracy of correct sex identification at hatching was 92.5 percent when the web area of the dorsal wing surface was used in sexing 103 chicks. The sex of 216 chicks was identified with an accuracy of 92.6 percent. Male chicks were required to have a relatively large white spot in the web region of the dorsal wing surface. The accuracy of sex identification was increased to 94.9 percent in 315 chicks by mating those whose dorsal surface color was uniform over the entire area. In a very light strain of New Hampshires the sex of 86.5 percent was correctly identified. It is suggested, for those who wish to improve sex identification in these two red-colored strains, that only those chicks having larger white areas on the dorsal surface of the wing web be saved. The general color tone does not need to be dark, but should be distinctly pigmented and uniform in both sexes. — R. G. JAAP. (Okla. Expt. Sta.). (*Poultry Sci.*, 25 (1946), No. 1, pp. 185-186.)

HEREDITARY CALLUS OF THE FOOT



A PEDIGREE OF SEVERE FOOT CALLUS

Figure 9

From the incidence of this affliction in two generations, it appears to be a dominant characteristic. The individuals in the third generation are children, in whom the characteristic may manifest itself after they reach puberty.

MR. A. N., white male, age 29, of English-German descent, was first seen on 9/12/45 with a complaint of calluses on the feet, of 20 years' duration. The calluses were painful, especially when walking. He was a grocery clerk which made it necessary for him to be on his feet all day. There was no history of arch trouble, hyperhidrosis, birth marks or previous treatment.

Physical examination showed a symmetrical hyperkeratosis of the soles of both feet and toenails. On the plantar surfaces of all toes, arches and heels were large plates of hyperkeratosis. The borders of the hyperkeratotic areas were about 5 mm. thick. Color was dirty yellow. There were no fissures. All the toenails were deformed and raised from the nailbed by thickened subungual hyperkeratosis.

Treatment consisted of X-rays, salicylic acid plasters, and scalpel trimming. At present about 90% of both soles are free of hyperkeratosis and most of his symptoms have disappeared.

Figure 9 traces the pattern of inheritance in this particular case. As seen in the diagram, it is a dominant characteristic and will probably appear in the third generation, after the children who are three and six years of age reach the age of puberty.

JEROME M. GREENHOUSE

MULTIPLE PIGMENT DEFECTS

Familial Chloasma-Like Pigmentations and Other Disorders of Pigmentation in a Hindu Family

FRANK PIERS
Nairobi, Kenya

THE following cases are recorded on account of the unusual coincidence of multiple rare pigmentation in three members of one family.

Pedigree of the Z. Family

The patients are Hindus of the Banyan (trader) caste. The four individuals in generation I (Figure 10) emigrated from a village near Bombay to Kenya Colony in 1920. The marriage between *Z.* and *A.* (cogeneration II) took place in 1928. Seven children were born between 1929 and 1945. *Z.* and *A.* are not related to each other, neither are their parents and grandparents. The Hindu religion strictly prohibits marriage between blood relations. Intermarriage with non-Hindus can be ruled out with certainty for the last three generations. Of the 28 individuals shown in the pedigree, three present disorders of pigmentation, namely *Z.*, and his children *S.* and *V.*

The normal coloring of the Hindu race is present in all other family members: a sallow, light-brown complexion, deep-brown irises, jet-black or dark-brown hair. The degree of these pigmentations varies within certain narrow limits. The sixth child for instance, a girl aged 4, is notably darker than the other sibs,—but this has to be considered as a normal variation.

Case Histories

Z., aged 34, clerk. He suffered from an attack of malaria in 1940; otherwise there is no history of systemic or endocrine disease. He is a well-built man of good intelligence. Skin light-brown, irises very dark-brown, hair black, curly. A yellow-brown ("café-au-lait") area of pigmentation occupies the upper two-thirds of the face, leaving out the upper lip, mouth and a region corresponding to the maxilla, thus producing a mask-like effect The skin within the pigmented area is of normal texture, and presents no abnormalities of surface except for a few scattered comedones and acne pustules near the naso-labial folds. The border between normal and pigmented skin is well defined in the region of the cheeks as a slightly serrated line.

Nothing is known about the time when this condition appeared; as it is not very conspicuous it seems to have escaped notice. Kahn Reaction: negative. Blood film: no malaria parasites; nothing to indicate visceral leishmaniasis (Kala-azar).

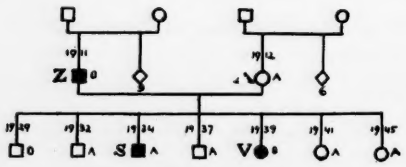
History of S

S., aged 11, third child of *Z.* and *A.*, a well-developed healthy-looking schoolboy of normal intelligence. Previous history negative; no sign of systemic or endocrine disease. The skin is generally of a healthy light-bronze color (darker than his father's). The irises are light-hazel; the hair is straight, dense, and of dark blonde color (said to be darker now than in infancy). Six months after birth "moles" were noticed to appear on both cheeks which became darker at the age of two, and have remained stationary since.

There is a symmetrical pigmentation which affects both cheeks (Figure 11). It originates near the inner canthi, follows the lower edges of the orbits and ends in the temporal regions, forming two wedge shaped bands with tapering ends. (Figure 11, upper left.) The color is a dark slaty brown, but smaller light spots within the band produce a somewhat mottled effect. The margins are sharply defined and slightly serrated. The texture of the skin is normal. The skin of the thorax is of normal color; but over the sternum a peculiar depigmented band is visible which divides into two branches which extend towards the clavicles, thus producing a Y- or V-shaped design. This area of depigmentation blends gradually into the normally colored skin, and includes a V-shaped darker colored triangle corresponding to the area exposed to light. Lanugo hair is present on face, thorax and extremities; it is very light, nearly white. Two keloid vaccination marks are present over the deltoid region of the left arm.

History of V

V., aged 6, a delicate-looking girl, the fifth child of *Z.* and *A.* Previous history negative, no signs of systemic or endocrine disorders. She is of normal intelligence for her age.



A POSSIBLE GENETIC DEFECT

Figure 10

The observations recorded in this chart, although showing a similar aberrant coloring in a father and two children, are not sufficient to prove hereditary transmission. The small letters, A and O, designate blood groups.

The general skin color is a light creamy brown, the irises are deep brown—in striking contrast with the hair which is fair, slightly wavy, and of a very fine silky texture (Figure 11). On the right cheek a pigmentation began to develop during the first few months of life; it has not progressed very much since, but recently traces of darker coloration became visible on the left cheek as well. On the right cheek a pigmented band is present which resembles in distribution, color and shape closely that of *S.*; but is generally smaller and less sharply defined. A diffused darkish pigmentation can be seen at close inspection in the region of the left orbit. The right upper eyelid shows an area of depigmentation of oval shape, with smooth, not hyperpigmented margins, about a half inch in diameter.

The vaccination marks on the right arm are atrophic scars. No other abnormalities are found.

Diagnosis

In the absence of systemic disease and of endocrine disorders, and in view of their congenital character, most of the lesions can be assumed to be of a naevoid nature.

The Hindu race is predisposed to facial pigmentations of an unusual, often symmetrical type. Castellani[1] described a "chloasma symmetricum" and a "chloasma bronzeum"; both were found in Singhalese (and in Europeans who had resided for a long time in Ceylon). Castellani thinks that these chloasma-like discolorations may be due to prolonged exposure to sunlight, and that they are not congenital. Gupta[5] mentioned a "melanoderma" of the face which shows "butterfly" distribution and varies spontaneously in intensity. These types of pigmentations obviously require further investigation.

The facial pigmentation of *Z.* is probably an ordinary naevus pigmentosus spilus ("liver spot" or "café au lait" naevus).

The symmetrical band-like pigmentations in *S.* and *V.* resemble chloasma uterinum in their arrangement; their color and the absence of epidermal changes are suggestive of lentigo. Not all cases of chloasma are symptomatic of pregnancy, endocrine disorder and abdominal disease.[6,7] The "idiopathic" forms are at present best classified as tardive naevoid pigmentations. Lentigines are occasionally seen in band-like or symmetrical systematized arrangements.[4]

The Y-shaped depigmented figure on *S.'s* chest stands perhaps in relation with the line of an embryonic cleft (fissural naevus?). A depigmented line is not infrequently seen over the sternum in strongly pigmented Indian children. The condition as seen in this case has apparently not been described previously. It does not seem to be dependent on exposure to sunlight on the upper sternal region.

The depigmented spot on *V.'s* eyelid is a typical "naevus depigmentosus."

Finally, the light hair of *S.* and *V.*, and the comparatively light iris of *S.* are suggestive of a rudimentary form of albinoidism. The texture of the hair, particularly in *V.* where it is fine, silky and slightly wavy, is frequently found in albinoids.[2]

Fair hair and light eyes occur not infrequently among Hindus as apparently recessive traits. I have recently seen two new-born Hindu babies with golden hair and and blue eyes both of whose parents were dark-haired and dark-eyed. The Hindu caste system with its limitation of selection favors the appearance of recessive traits. So do other social conditions among Indians, especially intermarriage between inhabitants of the same village and of the same district which often has been carried on for centuries. The chances of intermarriage among distant relatives are large within Hindu castes, in spite of the prohibition

FAMILIAL FACIAL PIGMENTATION

Figure 11

The mottled bands of coloration under the eyes are more marked in *S.* than in his sister *V.* This is a manifestation, in lesser degree, of the coloring of their father, the upper two-thirds of whose face bore a distinct mask-like pigmentation. Facial pigmentations of a naevoid type are not uncommon among Hindus, but the genetic basis for these remains to be studied further.

of marriage between *close* and *known* blood relations.

Comment

There is little to be gained by attaching a diagnostic label to each of the many pigmentary disorders separately. Three facts however emerge from this review of the lesions:

(1) The congenital character and the familial incidence.

(2) The presence of multiple naevoid disorders consisting of well defined hyperpigmented and depigmented skin areas.

(3) The additional presence of a rudimentary form of albinoidism in the same individuals.

These three factors combine to constitute a peculiar syndrone. Genetically, albinoidism seems to be recessive in this family. Both parents probably are heterozygous for it; the ratio of 5:2 between non-affected and affected sibs approximates the typical 3:1 ratio of recessive heredity.

The inheritance of pigmented naevi is still under discussion and no clearly-defined law has been found for it. In the case of flat pigmented naevi spili an irregular dominant mechanism seems to be responsible in many instances.[2] This is probably the case in the *Z.* family.

The question whether naevoid conditions and albinoidism, as in the cases presented here, are merely coincidental[3] or due to genetic linkage, has to be left open. It will be necessary to study more than a group of three cases to decide the genetic character of this rare syndrome.

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◆

A Suggestion for Recording Case Reports

MOST research workers in biology and medicine are at one time or another confronted with a dilemma when they contemplate publishing abnormal findings in single cases or small groups of individuals. Many observations of this kind are, on the one hand, worth recording, but, on the other hand, not worth the space of a full-sized article in a journal; they must either be forgotten or reported in undue length. Particularly geneticists and pathologists often regret that so many single observations are not published which, when gathered, would be of great value. To avoid this, it is suggested that a central distributing agency receive and print brief casuistic reports with a few words of discussion and key references on the two pages of single sheets. These would be offered on a subscription basis for filing according to the subscribers' own requirements. It would be desirable to publish this in several sections for workers in different fields of biology and medicine.

At the present time the service of the American Documentation Institute is available to record observations which are beyond the range of the usual means of publication. The method herewith suggested is different in that it would reach the reader without the necessity of ordering single reports which have to be listed in journals. However, cooperation of the A. D. I. by recording additional information could greatly increase the value of the new system suggested here.

It is hoped that this suggestion will open a discussion in which a satisfactory method of publishing case reports can be worked out.

Peter Gruenwald
Mount Sinai Hospital
New York City

THE HEJAZ DWARF GOAT

H. EPSTEIN*

OUR knowledge of the goats of Arabia is very imperfect. References to them are few and far between and exceedingly contradictory. Stegmann von Pritzwald writes: "The Arabian goat is characterised by a Roman nose and pendent ears. Owing to its high legs and consequent quick gait, it is well adapted to the steppe-like region of its distribution and therefore a valuable part of the flocks of the Arabs."[15] While this statement may be correct with regard to some of the goats in the countries north and west of Arabia, it certainly does not apply to the goats of the Arabian peninsula, especially those of the province of Hejaz and the western parts of Nejd. C. Keller[8] is hardly more exact when attributing to the goats of Arabia and the Syrian desert ears never pendent, but always erect or laterally directed, a dense coat of medium length, blackish-brown, red-brown or variegated in color, and a very large udder, often reaching down to the ground. Stegmann von Pritzwald[15] referring to the dwarf goats of Africa mentions that a similar small domestic goat is found in Arabia. According to Duerst,[3] dwarf goats are found in Central Africa, India, Arabia and Siberia; but Hilzheimer[6] says that the dwarf goat "does not seem to occur outside of Africa."

In 1943, as Technical Adviser (Meat) to the Government of Palestine, the author had an opportunity of handling approximately ten thousand goats that had been brought under a contract from Hejaz to Palestine for slaughter purposes. The experiment was not repeated as the animals proved of poor slaughter value and could not be kept on grazing for any considerable time, being quite unadapted to the environmental conditions of Palestine.

In Hejaz, the 'barrier' between Nejd and the Red Sea, these goats are bred by the nomads of the desert, along with camels and sheep. Hejaz is among the regions of Arabia least favored by nature, second only in desolation to the deserts of Nefud, Dahana, Rub al Khali and El Ahkaf. From the narrow sandy coastal strip (Tehama) with its extremely hot climate the country rises in steep escarpments broken by deep gorges to a high plateau up to 1880 meters above sea level, divided, by the Wadi Hamdh, into Midian in the north, and Hejaz proper in the south. The northern parts consist of sandstone, and the southern of basalt. In winter the western winds carry a little rain (less than 250 mm. on an annual average) filling the mountain wadis and producing a short season of sparse steppe vegetation on the highland. For the rest of the year the country resembles a desert habitable only around the oases where some grain, fruits and vegetables are grown.

Description

The goats of Hejaz are of a remarkably uniform type, suggesting a long past uninfluenced by introductions of goats from other lands. Their outstanding characteristic is the small bodily size, the withers height rarely reaching 60 cm. But the general conformation shows harmonious proportions and nothing of the grotesqueness associated with some forms of dwarfism.

The head is of medium length, with a broad convex forehead separated from the chaffron by a slight depression below the region of the eyes. The facial profile is characterised by the bulging forehead, more especially in the male, and the straight nasal portion. The head is wedge-shaped, ending in a pointed muzzle, with both jaws of equal length. The long slender wavy ears have a lateral direction and are freely moved forward and backward. Occasionally the auricula is atrophied, and this condition, never observed in goats from Syria, Iraq or Egypt, occurs in every degree of

*Technical Adviser (Meat), Government of Palestine.

SKULL ANATOMY

Figure 12

A-B—Top and front views of a female skull, the former with the horns removed. Side view (*C*), and front view (*D-E*), of skull of male. The skull of the Asia Minor Goat (*Capra hircus aegagrus—F*) has straighter horns but otherwise rather closely resembles the Hejaz type.

HEJAZ MOTHER WITH KIDS

Figure 13

Single kids or twins are the usual numbers at a birth. Though the symmetrical type of dwarfism characteristic of these goats would be classified as a pituitary deficiency, fertility is not reduced. Milk production is very poor.

variation between a perfect ear and an ear of which only the scantiest vestige remains. Absence of the auricula is a mutant character based on a single mendelian factor. In crossing earless goats with animals having normal ears, the entire first filial generation carries ears about half the normal size. If such short-eared goats are interbred, the F_2 generation is composed of 25 per cent homozygous earless goats, 25 per cent homozygous animals with ears of normal length, and 50 per cent heterozygous short-eared specimens.

Some Hejaz goats have a short beard restricted to the chin; but wattles are rare. The eyes are large and prominent. The horns leave the head in the plane of the forehead, then curving downwards in the form of a sickle or scimitar. In the male the tips of the horns are sometimes turned outwards, but rarely to such an extent as to form a twist. Occasionally the horns describe a full circle close to the face. The neck is long and slender, although this is not so conspicuous in the male. The withers are not very prominent, the chest is of medium depth and width, the back is short and straight, and the croup only slightly drooping. The tail is set high and turned up on the back. The legs are strong and well placed, with broad flinty hoofs. The udder is small and the milk production negligible. Apart from the larger size of the horns, the secondary sexual characteristics of the male are not prominent. The body, including the upper part of the neck and legs, is covered with a shaggy coat of medium length. The face, lower part of the neck, and the legs from the knees and hocks downward are short-haired. The general color of the coat is black, sometimes with

ANCESTORS OF THE GOAT

Figure 14

Capra hircus aegagrus. This sub-species of the wild goat extends from the Caucasus through Asia Minor and eastward to Persia and India. This may have been the type from which the Hejaz goat was descended. The turbary goat of the ancient Swiss Lake dwellers was also a dwarf, possibly a distant relative.

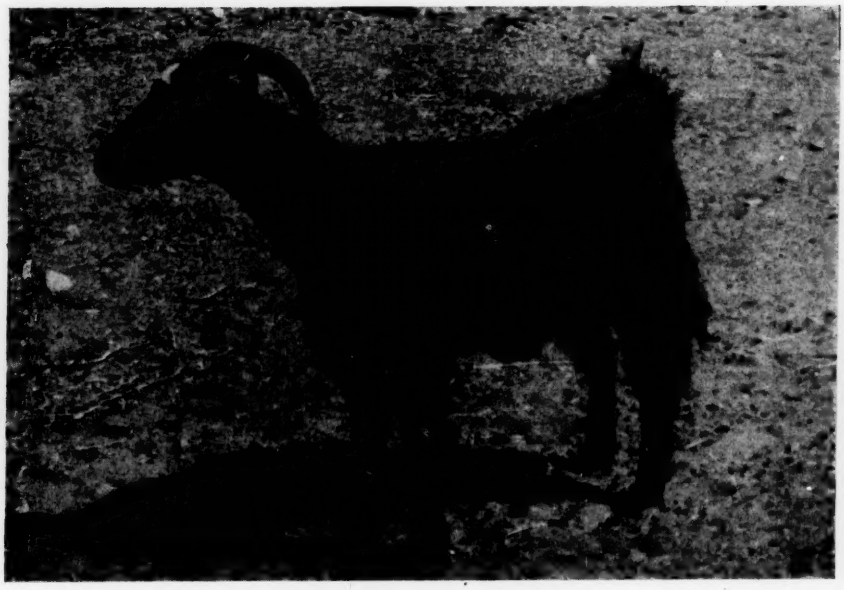
a slight reddish tint and a white star on the forehead. Occasionally the black color is broken by one or two streaks of brown extending from the ear to the corner of the mouth. The color of the horns is a blackish-olive. The average live weight taken from more than five thousand animals is 22 kilogrammes in the mature male, and 19 kilogrammes in the female. The dressing percentage is approximately 35 per cent, what little meat there is being stringy and of poor quality. The doe gives birth to one or two kids at a time, each weighing about two kilogrammes at birth. During the first weeks their ears are slightly pendulous, but with the strengthening of the muscles they become erect.*

Pituitary-Type Dwarfism

The diminutive bodily size places the Hejaz goat among the dwarf breeds. Dwarfism is the term applied to a collective concept comprising all individuals whose bodily size remains considerably below the accepted average.[18] In domestic goats two different hereditary types of dwarfism occur; achondroplasia and pituitary hypoplasia.

Achondroplasia is characterized by a marked difference in bodily proportions. There is an average size trunk coupled with abnormally stunted extremities. Achondroplastic goats are distinguished by the abnormality of cartilage bone formation arising in fetal life, and resulting in a deficient growth of the long bones, causing dwarfism with long body but short limbs. It is generally agreed that achondroplasia is not endocrine in origin.[17]

*Six pages of additional detailed anatomical data assembled by Dr. Epstein are available as a supplementary document. To obtain this material, order Document No. 2339 from American Documentation Institute, 1719 N St., N. W., Washington 6, D. C., remitting 50c for microfilm or 60c for 6 x 8 inch photocopies.—Ed.



HEJAZ BILLYGOAT

Figure 15

The legs are strong and well placed with broad flinty hoofs. Some males have a prominent beard, but this is not a universal characteristic. The uniform type of the Hejaz goat, and the marked differences between it and goats in neighboring regions suggest that this peculiar breed is very old.

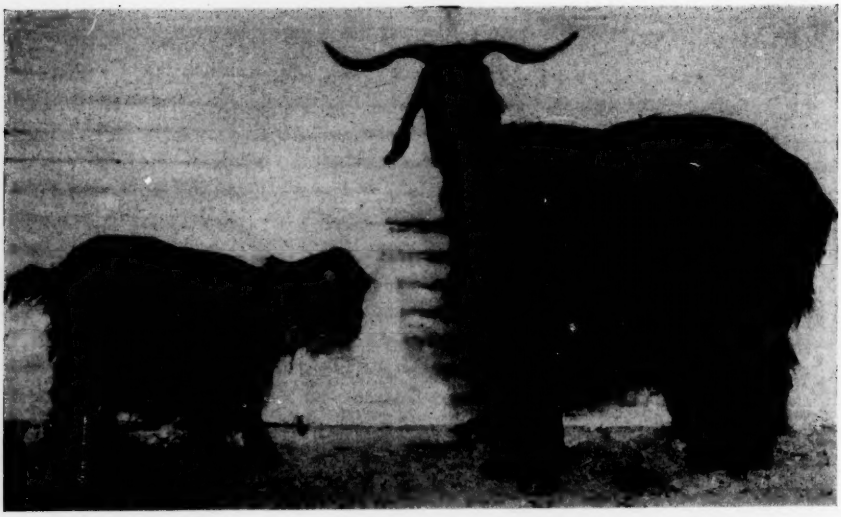
Achondroplasia is usually considered to be associated with the germ-plasm itself. Evans and his associates have ruled out the possibility of pituitary involvement. They have injected daily a preparation of the growth principle, freed from the gonad-stimulating principle, into a number of dachshunds typifying achondroplasia. The animals increased greatly in size over the controls, giganism being definite, but still retained the achondroplastic form of the short extremities.[2]

From this account it is obvious that achondroplasia is not involved in the case of the dwarf goats of Hejaz whose small stature is due solely to pituitary hypoplasia. The latter is characterised by a hereditary underdevelopment affecting all parts and organs of the body alike so that the entire skeleton, with the exception of the neurocranium, is well proportioned. However, the relatively large size of the neurocranium does not appear to be a primary disposition, being due to physiological factors.

Pituitary hypoplasia is defined as a general arrest of growth and development of all organs and systems of the body because of a hereditary hypofunctioning of the growth principle of the anterior lobe of the pituitary.[5] Since neither sexual development nor general glandular constitution is affected, there seems to be an inherited deficiency in the secretion of merely the hormone controlling growth. This makes for an individual of short stature, but which is otherwise normally developed, proportionately built and of normal sexual development.[2]

How Does A Dwarf Variety Arise?

Three factors seem to be involved in the evolution of a dwarf breed of domestic goats, namely, natural selection, artificial selection, and inbreeding. It ap-



HEJAZ AND TURKISH GOATS

Figure 16

The Hejaz goats are a remarkably uniform dwarf type, rarely exceeding a height at the withers of two feet. They are well proportioned and active. The dwarf stature appears to be due to a combination of natural and artificial selection of a type adapted to an unfavorable environment.

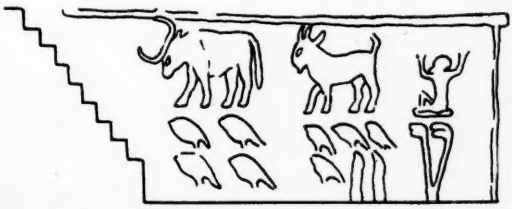
pears that poor environmental conditions, more especially a scarcity of grazing, promote the evolution of a diminutive size in domestic animals. Under such conditions dwarf mutants are seemingly more highly adapted than the bulk of the ordinary stock, the pressure of selection bringing about a gradual alteration of the stock by the slightly higher survival- and reproduction-rate of dwarf types. Owing to the breeders' experience of the greater hardiness and better condition of the smaller animals in their flocks under unfavorable environmental conditions, natural selection has doubtless been frequently supported by artificial selection of diminutive mutants for breeding purposes. In the case of the dwarf goats of Hejaz close and continual inbreeding, held to explain the small bodily size often encountered in island fauna, might have been a contributary factor, increasing the rate of combination of recessive mutant genes governing pituitary hypoplasia. Huxley,[7] however, does not mention this factor, ascribing the evolution of dwarf forms on islands or near the limit of their range solely to selection in relation to somewhat unfavorable conditions.

Since dwarfism in the Hejaz goat is obviously due to mutation and subsequent selection, similar mutations may be expected to occur independently in other goats as well. And indeed, such pygmy goats are known in several parts of the world, as, for instance, in Siberia, India and Equatorial Africa. Similar goats occurred also in the Swiss lake dwellings as well as in Egypt at the time of the dynastic conquest. Bones of a dwarf goat have been found in the kitchen middens of the predynastic inhabitants of Toukh, south-east of Abydos, while the animal is represented by an ancient rock engraving at Assuan, on an ivory knife handle from Gebel el 'Araq, and a carved mace head of Narmer, first king of the First Dynasty. These goats are of particular interest as they seem to have closely resembled the Hejaz goat. (See Figures 17 and 18.)

FIRST DYNASTY ANIMAL HUSBANDRY

Figure 17

Scene from the mace-head of Nar-mer. The goat resembles the Hejaz type in conformation. The relative sizes of ox, goat and man hardly suggest that the artist was drawing his subject study to scale.



Origin of the Hejaz Goat

The turbary goat of the lake dwellers of Switzerland was an animal of very small stature. The main characteristic of its fossil remains are the slender horn cores which are generally more strongly developed in the male than in the female. They are situated in the prolonged plane of the forehead, forming but rarely an obtuse angle with the latter. Viewed from the front they appear quite straight and parallel. In accordance with the position of the horns, the cranial profile is dished rather than convex. The interior of the horn core is completely sinuous, with very few diploic walls. There is a number of vascular and cutaneous furrows on the outside.[3]

According to Ruetimeyer,[13] the turbary goat is distinguished by its slender, compressed and lens-shaped horn cores which are remarkably pointed at the tips and placed vertically upon the skull at a distance of 25 to 30 millimeters. Duerst has pointed out that in older males the cores become almost triangular in cross-section and very thick.[4] Augst,[1] however, in rejecting Duerst's description, states that he has never found a triangular core, the horn cores in the turbary goat always being pear-shaped with a sharp keel in front, that becomes rounded in aged males, which are therefore devoid of any keel on the lower third, and more, of their length.

According to Duerst,[4] cranial fragments of the turbary goat, especially of the female, show complete conformity with the skull of *Capra hircus cretensis,* the smallest sub-species of the wild *Capra hircus.* This is significant in view of the fact that all authors on this subject, with the single exception of Augst,[1] consider the domestic goat breeds furnished in both sexes with sickle- or scimitar-shaped horns to be descended from the wild *Capra hircus* of the Asiatic mainland. This goat is distinguished by the long scimitar-shaped horns of the male which are considerably compressed, with their inner front edge forming a sharp keel for some distance above the base and above this marked with irregular prominences. The horns are practically flat on the inside, but convex externally and rounded behind, with the tips generally convergent, occasionally divergent. *Capra hircus* is divided into four subspecies or geographic races: *Capra hircus aegagrus,* the range of which extends from the Daghestan district of the Caucasus through the mountains of Asia Minor and Persia, including the Kopeth Dagh, to the confines of Baluchistan and Sind; *C. h. blythi,* of Sind and Baluchistan; *C. h. cretensis,* of Crete; and *C. h. picta,* from Antimilo (Erimomilos), Cyclades.[10,11]

It is not known where the ancestors of the dwarf goats of Hejaz were domesticated. They seem to have reached Arabia at a very early period, possibly in the train of the Pūn people who, according to Petrie,[12] originated in the Caucasus and Elam whence they went down the Persian Gulf and settled in the Horn of Africa, the land of Punt. Those who went up the Red Sea formed the dynastic invaders of Egypt; others went on to Syria and founded Tyre, Sidon and Aradus. It is possible, however, that the Hejaz goat goes back to an even earlier wave of immigrants, the first pastoral folk that entered the Arabian peninsula long before the passage of the Pūn people.

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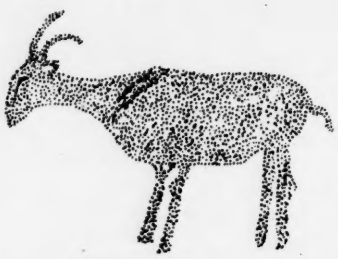

Figure 18

ANCIENT ROCK DRAWING FROM ASSUAN

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